Finally the author discusses secular temperature changes as indicated by thermometric measurements made in the last 100 or 150 years, and concludes that at Haparanda, Stockholm, and Lund, in Sweden, the January temperature has risen during this time 1° C., while that of August has become somewhat cooler. At Lund, April, June, September, and October temperatures have remained unchanged.

The paper contains five figures. One of these shows the fossil and present distribution of Hazel in Sweden.

This article is particularly interesting to one who has previously read Chamberlin's papers on the same questions. There are several points of coincidence in the two. One of the authors is a meteorologist, the other a geologist, by profession. On the main cause of long-periodic changes of climate both agree. In accounting for minor details the geologist favors meteorologic causes, while the meteorologist seems inclined to accept, with a modification, a hypothesis which has been quite generally favored among geologists.

J. A. UDDEN.

Sveriges temperaturförhållanden jämförda med det öfriga Europas. [The Temperature Conditions of Sweden compared with those of the rest of Europe.] By NILS EKHOLM, *Ymer*, Årg. 1899, H. 3, pp. 221–242. Published by Svenska Sällskapet för antropologi och geografi, Stockholm.

The only portion of this paper that has obvious geological bearing is the statement that the temperature conditions of Sweden, especially the cold winters which sometimes occur, are to be explained rather by exceptional conditions favorable to radiation than by cold winds coming from Siberia. The author shows, among other things, that the recurrence of cold winters in Sweden exhibits a quite definite periodicity of five and two thirds years, or half the length of the sun-spot period.

J. A. UDDEN.

Physiography of the Chattanooga District in Tennessee, Georgia, and Alabama. By C. WILLARD HAYES. United States Geological Survey. Part VII, Annual Report, 1897–8.

In this report the author has done what Gilbert did in his "Geology of the Henry Mountains," namely, has made a study of a region

where the conditions are more or less simple, with a view of establishing principles which may be used in regions of greater complexity. The region concerned is situated in southeastern Tennessee, northeastern Alabama, and northwestern Georgia. It is bounded by the meridians of 84° 30′ and 86°, and by parallels of 34° and 36°, and comprises nearly 12,000 square miles.

The problems considered are as follows: (1) The forms assumed by maturely adjusted streams in a region where the strata are faulted and folded, and where metamorphism has so affected the rock that the original differences have been diminished, leaving a somewhat homogeneous series; (2) the forms assumed by streams when the strata are practically horizontal, and where the beds vary greatly in hardness; (3) the processes by which consequent drainage in a region of folded strata is transformed into subsequent drainage, with the development of anticlinal valleys and synclinal ridges; (4) the present altitude of former base-levels and the determination of the deformations which the region has suffered in recent geological time. These problems are considered under two main heads, namely, "Geomorphology" and "Geomorphogeny."

The Chattanooga district embraces a part of each of the five natural divisions into which the southern Appalachian province has been divided by Powell.[1] Within this region Hayes finds three types of topography: (1) The Western type, including the Cumberland plateau and the Highland Rim, a part of the interior low lands; (2) the Central type, and (3) the Eastern type.

(1) The first or Western type is separated from the other divisions by the Cumberland escarpment, which forms the eastern boundary of the Cumberland plateau. In the northeastern portion of this district streams have hardly begun to cut in the plateau, while to the south and west only remnants of the plateau remain, each remnant retaining the characteristics of the original highland. The plateau is about 1800 feet above sea level, the Highland Rim about 1000 feet, while the low lands, which stretch northwestward to the Ohio River, have an altitude of but 600 feet. Thus it is seen that the Highland Rim is a terrace between the Cumberland plateau and the lowland. (2) The Central type is that of the Great Valley, in which there are three levels or sets of levels. The valleys of the Tennessee and the Coosa rivers are from 600 to 700 feet above sea level. One series of valley ridges reaches

[1] Physiographic regions of the United States: Nat. Geog. Mag., Monograph No. 3.

altitudes of from 900 to 1100 feet, and another altitudes of from 1500 to 1700 feet. (3) The Eastern type comprises the Unaka Mountains and the western portion of the Piedmont Plain.

The formations of this region are divided into two groups: (1) The unaltered sedimentaries which are of varying degrees of hardness and solubility, and (2) the metamorphic and igneous rocks.

The twenty-three formations of the Paleozoic are divided into five subgroups: (1) The lowest six Cambrian formations consist of conglomerates, quartzite, and siliceous shales, and are nearly insoluble. These form the rocks of the Eastern division. (2) Ten Cambrian and Silurian formations, composed for the most part of limestone and shales, are relatively soluble. These occupy the greater part of the Valley or Central division, while a few beds of sandstone and the Knox dolomite give rise to the valley ridges. (3) The Upper formations of the Silurian and the formations of the Lower Carboniferous are the rocks which form the Highland Rim, and also some of the valley ridges. (4) On account of their solubility, the Lower Carboniferous series gives rise to the characteristic topographic forms in the Western division. (5) The durable Coal Measures conglomerates cap the Cumberland plateau and have occasioned the preservation of large areas of its surface.

The second group of rocks, that is, the igneous-metamorphic group, comprises, (1) the feldspathic (easily eroded) rocks which form the larger part of the Piedmont plateau, and (2) the non-feldspathic (resistant) rocks which have given rise to the irregular topography of the Unakas.

In this region Hayes makes out three peneplains or base levels, namely, the Cumberland base level, the Highland Rim base level, and the Coosa base level.

The altitude of the reconstructed Cumberland base level at its southern edge is about 1200 feet. From this altitude it increases to a height of 2000 feet in the central part, and decreases again to 1600 feet along its southern and eastern edges. This gives a gradient of ten feet per mile from the edges to the center, which is steeper than a base level grade should be, and, besides, no base level tract should have such a shape unless drainage radiated from its center, and this does not seem to have been the case. Hayes explains the present form by the hypothesis that in being elevated to its present position the base leveled region was warped into the form of a low dome. Upon

the peneplain are a few remnants above the general level. The Cumberland base-leveling epoch came to an end with the uprising at the end of the Cretaceous.

The Highland Rim is the peneplain next below the Cumberland. It retains a very uniform height, the difference between the northern and southern edges being but little more than existed during the period in which it was base leveled. Upon this plateau also there are monadnocks which represent areas of more resistant rocks.

The altitude of the lowest and youngest peneplain is 700 feet at the south and 800 feet at the northern edge. Here, as upon the other plateaus, there are considerable variations in altitude in different parts of the peneplain. These should not be taken as indicating distinct base levels, but simply the influence of local conditions.

Hayes considers two hypotheses in explanation of these peneplains, namely, subaërial denudation and marine denudation. He finds support for the former only.

The streams of this region belong to three distinct river systems, the Cumberland, the Tennessee, and the Coosa. They are the main agents which have shaped the present topography. There have been periods of stability and relative inactivity, alternating with great revolutions. It is hard to follow all these changes in detail, for the history of each change is in some measure obscured by that of the next. The first cycle of erosion resulted in the formation of the Cumberland peneplain. This cycle began when the land was raised at the end of the Carboniferous, and ended with the uplift closing the Cretaceous. This long period of erosion was not a single cycle, but was composed of a number of more or less distinct cycles, the evidence of which remains even to this day. Hayes has worked out the general courses of the Paleozoic streams in some detail, but no statement would be intelligible without the maps.

When the Cumberland peneplain was raised and warped, and the second cycle of erosion inaugurated, there were signs of activity all along the line. The sluggish streams began again to cut their beds and to fight for the mastery of favorable positions. The development of new streams at the expense of the old, changes in the direction of drainage, and final, almost perfect, adjustment of the streams in this cycle are carefully worked out by the author. This second cycle, while much shorter than the first, extends over a vast period of time. It ended, as did the Cumberland, by a rise of the land and a slight

warping of the surface. The streams again began to adjust themselves to their new conditions, a work in which they are still engaged.

Hayes has made out the following changes which the streams have gone through in reaching their present courses. First, they moved westward to the interior sea as antecedent streams during the first cycle. Then they were diverted southward to consequent courses, and at last flowed westward as subsequent streams.

The way in which peneplains are correlated forms an interesting section of the paper. The types of stream basins as found in the region are vividly described. The maps, of which there are five, repay careful study.

F. H. H. C.

Geology of Minnesota, Final Report, Vol. IV. By N. H. WINCHELL, U. S. GRANT, WARREN UPHAM, and H. V. WINCHELL. Quarto, pp. i–xx, 1–630, with 31 geological maps, 48 photographic plates, and 114 figures. St. Paul, 1899.

This volume, which completes the areal geology of the state, follows its predecessors in the geographic arrangement of the subject-matter. The area covered embraces the northern third of the state, and includes some thirty counties and districts. The bed rock of the region, with the exception of scattered patches of Cretaceous, is almost universally crystalline in character, and is referred to the Archean and Taconic. The thickness of the drift is very great throughout most of the region considered, several counties in the northwestern part of the state presenting no outcrops whatever of the bed rock.

The crystalline rocks in this largely new field have naturally received much attention, resulting in the accumulation of a considerable mass of new facts relating to the Archean and Taconic, especially the former. The interpretations based upon these facts differ considerably from the commonly accepted views as to the character and divisions of the ancient crystalline rocks, and especially as to the assumed representative of the original crust of the earth.

It is to be regretted that the first presentation of a new classification should be somewhat lacking in clearness, but nowhere in the volume is there a satisfactory statement of the divisions into which the various clastic and igneous rocks of the state have been separated, nor of the equivalents in the ordinary classifications. As nearly as